Global Bioenergy Partnership

- White Paper -

THE GLOBAL BIOENERGY PARTNERSHIP

– WHITE PAPER –

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Summary

Global energy supply will face significant challenges over the next century. These include ensuring security of energy supply, greenhouse gas concentration stabilisation in the atmosphere to levels that will limit damage from climate change, reducing other negative impacts of energy supply on the environment, and providing access to energy to the world's poor.

Biomass contributes about 10% of world primary energy supply, predominantly as traditional fuels for cooking and heating. In industrialised countries, the biomass contribution is in the range of 2-4%. There is significant potential to increase its contribution for the provision of heat, electricity and transport fuels. Furthermore, biomass can contribute to addressing the challenges facing energy supply and can be accompanied by other socio-economic benefits. However, the deployment of bioenergy faces technical, economic, social and regulatory barriers, and the bioenergy sector and related policies and markets are still at an early stage of development.

A number of international activities are already at work to assist the development and deployment of bioenergy in developed and developing countries, but additional action at the international level is needed to accelerate the expansion of sustainable bioenergy. This was recognised by the G8 Leaders in Gleneagles Communiqué endorsing the launch of a Global Bioenergy Partnership to support wider, cost effective biomass and biofuels deployment, particularly in developing countries.

The objective of this White Paper is to discuss how the Global Bioenergy Partnership could contribute to the development and deployment of bioenergy in developed and developing countries, based on a review of the barriers facing bioenergy, existing international activities directed at bioenergy development and deployment, and the identification of areas of action where it is believed that a Partnership could add value.

The White Paper identifies fives areas where the Partnership could have an important role:

- Supporting national and regional bioenergy policymaking;
- Facilitating international cooperation in bioenergy;
- Promoting development of bioenergy projects and markets;
- Supporting biomass feedstock supply through information and research;
- Encouraging development and transfer of biomass conversion technologies.

In each of these areas, the Partnership role could include activities such as:

- Political engagement and promotion of bioenergy;
- Integration and leverage of international activities;
- Exchange of information, knowledge, skills and technologies;
- Facilitation of bioenergy integration into energy markets e.g. through activities related to standards, certification, international trade, etc.;
- Promotion of RD&D and market-building activities.

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1 Introduction

1.1 World energy challenges

Global energy demand is increasing rapidly. According to the International Energy Agency (IEA) World Energy Outlook reference scenario, economic growth and increasing population will lead to an increase in global energy consumption of 1.8% p.a. between 2000 and 2030. Although energy demand is rising slowly in industrialised countries, rapid growth is being experienced in developing countries: in 2030 about 55% of the global energy demand will come from developing countries, compared with 40% at present.

This demand is expected to be supplied predominantly by fossil fuels. The IEA World Energy Outlook reference scenario estimates that in 2030 fossil fuels will account for about 90% of the total energy demand. Oil will remain the main energy source (34%), followed by coal (29%) and natural gas (26%). Supplying energy in this way is likely to lead to significant pressure exerted on the environment, on natural resources, on public health and wellbeing, and have significant impacts on energy security. Such an evolution of energy demand poses four main challenges:

- Global carbon dioxide (CO_2) emissions are expected to increase by 2.1% p.a., corresponding to an overall increase by 2030 of around 60%. These emissions will come increasingly from developing countries: from 30% of total emissions in 1990 to over 50% in 2030, with 25% from China alone. The Intergovernmental Panel on Climate Change suggests that to ensure a level of stabilisation of CO_2 concentration in the air that does not lead dangerous increases in the average temperature and sea level, CO_2 emissions will have to be reduced by at least 50% by 2025-2030 compared with 1990 levels. An enormous effort is necessary in terms of research and innovation, as well as effective measures, aimed at the reduction of CO_2 emissions, involving both industrialised and developing countries.
- One billion people will not have access to electricity. This is a priority in the fight against poverty and for the achievement of the Millennium Development Goals (MDGs). New sources and technologies for clean and safe energy must be available and be cost-effective
- Energy supply will depend mainly on a few regions, some of which characterised by political and social instability. Diversification of energy resources and more efficient energy technologies are needed to reduce vulnerability and to ensure energy security
- Emissions of other pollutants such as nitrogen oxides (NOx), volatile organic compounds (VOCs), and particulates from vehicles will be more than twice those of 1990, with effects both on the human health and on crop productivity. The increasing external healthcare costs due to air pollution, especially in urban areas in developing countries, will require development and deployment of low-emission fuels and engines

Successfully overcoming these challenges would mean:

- Ensuring sustained quality of life in industrialised nations, and achieving a more rational and environmentally benign use of natural resources

- Accelerating the progress and quality of life in economies in transition and the prosperity of poorer regions of the world
- Providing worldwide opportunities for process and product innovation and, consequently, opening new and alternative markets
- Benefits for other sectors such as agriculture, forestry, land, and water systems, which are linked to the energy challenges mentioned. Furthermore, protection and restoration of the natural environment, as well as the development of rural communities, could alleviate the burden of poverty, whilst mitigating migration fluxes.

1.2 Introduction to bioenergy

Biomass is solar energy stored in the chemical bonds of organic molecules through the process of photosynthesis. Biomass is a multipurpose material which has been used for thousands of years for food, feed, energy and material. At present, biomass supplies 11% of world energy demand, predominantly as traditional fuels for cooking and heating. In industrialised countries, the biomass contribution is in the range of 2-4%.

Commercial biomass-to-energy (bioenergy) systems have been widely explored in the last 20 years. Organic materials which may be used as renewable energy sources have expanded: agriculture and forestry residues, agro-industrial by-products, municipal solid and liquid wastes and dedicated agricultural and forestry cultivation. Mature technologies are available for converting biomass into thermal and electrical energy or into liquid and gaseous fuels. The box below provides definitions for types of biomass feedstock, conversion processes and end uses.

Some definitions

Solid biomass: covers solid non-fossil material of biological origin which may be used as fuel for bioenergy production. It comprises:

- Purpose grown wood (from agriculture or forestry), conventional crops (e.g. sugar, oil and starch crops), wood wastes (e.g. from forestry or wood processing activities), other solid wastes (e.g. straw, rice husks, nut shells, poultry litter, biodegradable fraction of municipal solid waste).

Liquid biofuels: liquid fuels derived, comprising:

- Bioethanol, biodiesel, biomethanol, biodimethylether, biooil.

Biogas: a gas composed principally of methane and carbon dioxide produced by anaerobic digestion of biomass, comprising:

- Landfill gas, sewage sludge gas, other biogas e.g. from anaerobic fermentation of animal slurries and of wastes in abattoirs, breweries and other agro-food industries.

Bio-hydrogen: hydrogen produced from biomass for use as an energy carrier by several routes e.g.:

- Gasification or pyrolysis of solid biomass
- Reforming of biogas
- Novel technologies based on use of photosynthetic algae or bacteria, or on fermentative bacteria

The use of bioenergy can have benefits in relation to global climate, air quality, land and ecosystem protection, human health, as well as providing energy security through diverse and

local production routes. Modern technological solutions for converting biomass into energy increase these benefits, and increase their competitiveness with regard to conventional energy sources. Furthermore, biomass can be used for the production of high value chemicals. This can be done in combination with energy products in biorefineries. Although not specifically addressed in this White Paper, the production of biochemicals could provide important synergies with bioenergy development and deployment.
Bioenergy can contribute to the sustainable development of developing countries, as well as the achievement of the Millennium Development Goals.

1.3 Main drivers for bioenergy use

The challenges above translate into a number of interlinked drivers that should push for an increased development and deployment of bioenergy systems. The relative importance of the drivers varies depending on the routes and regions they apply to.

Climate change mitigation
The reduction of greenhouse gas emissions from stationary and transport sectors is a key driver for bioenergy use, principally in Europe. Bioenergy use reduces emissions when displacing fossil fuels, as the CO_2 produced during the combustion of biomass is balanced by the CO_2 absorbed by the plants during their growth. As a result biomass use involves no net increase in atmospheric carbon, except for the CO_2 released when fossil fuels are used for biomass harvesting, transportation and conversion – which can be very low. Also, in the case of increased forest productivity, CO_2 emissions can be negative since more CO_2 is being taken up and converted to biomass than was emitted by the slower-grown predecessor crop.

Atmospheric pollution
Burning biomass or using liquid biofuels in engines, may result in lower emissions of regulated air pollutants compared to the use of fossil fuels. For example, solid biomass and liquid biofuels results in minimal emissions of sulphur oxides (SOx). Use of biocomponents as liquid fuel oxygenates can reduce emissions of carbon monoxide (CO, an ozone precursor), and control pollutants contributing to photochemical smog. Biofuels also have lower emissions of heavy metals, as well as of carcinogenic substances, such as benzene molecules. Furthermore, biocomponents can be used to replace lead in gasoline.

Energy security
As discussed above, bioenergy systems involve a wide range of feedstocks, conversion plant at varying scale, and can contribute to energy supply in several sectors. This diversity can contribute greatly to energy security, and can allow indigenous production, reducing dependence on imported fuels, especially in the transport sector. This driver is particularly strong in the US, adding to support for ethanol production from corn, and in China, where reducing dependence on imported oil is a key component of national energy policy.

Rural development
Biomass energy systems can contribute to maintaining employment and creating new jobs in rural areas, avoiding land abandonment and population urbanisation. New crop types, and the ability to use agricultural and forestry residues provide diversification for existing farmers and landowners.

Excess crop harvests, for example, have driven ethanol programs in some regions of China. Local production of non-traditional energy, such as transport fuels and small-scale heat and power generation can contribute to rural development, especially in developing countries. Conversion plants and the development and deployment of new end use technologies are also a source of employment.

Soil protection and land reclamation
Growth of biomass feedstocks can help to restore degraded land and reclaim land through the use of energy crops for bioremediation. Short rotation woody crops can also be used for recovering abandoned lands and maintaining their function. Cultivating selected plant species must be planned and managed to minimize negative unintended consequences

Waste treatment
Hundreds of million tons of residues and wastes are produced every year. Even after considering other uses of some of these, such as animal feed, traditional energy uses and other industrial uses, there is still a significant resource which can be used, and in many cases needs to be disposed of in an environmentally sound way. Straw, rice husk, sawdust, bark, animal wastes, black liquor, bagasse, pruning residues, municipal solid wastes and many other wastes, can be used as source of energy. For example, in the EU, recovery of energy from the biodegradable fraction of municipal solid waste could be a valuable means for reducing the volume of wastes sent to landfill, as required by the Landfill Directive. Increasingly strict waste legislation in many industrialised countries and increasing urbanisation in developing countries will lead to waste treatment becoming a stronger driver for bioenergy production.

Employment, migration mitigation and social cohesion
Bioenergy can create jobs in many different economic sectors. However, the greatest value of bioenergy schemes with regard to employment lies in the fact that jobs are generated where there is great need for them, especially in rural areas where job maintenance and creation and economic growth are issues of particular concern. Farming, forestry, biomass distribution and energy services activities involved in the bioenergy chains generate direct and indirect jobs. Various studies mention the important employment potential associated with bioenergy, with employment figures in the range of 100,000 to 800,000 person - year / EJ of biomass.

Many rural and forestry areas all over the world suffer from migration of rural population to more industrialised regions. This often leads to land and socio-economic degradation in the abandoned areas. Biomass can contribute in many ways to the economic development and enviornmental preservation of rural areas, and reduce migration away from these areas. It can produce feed, food and energy, and its by-products recycled back the land (e.g. compost), to sustain local populations.

Bioenergy can favour social cohesion as its successful implementation generally involves a wide range of stakeholders (e.g. land owners, agricultural and forestry businesses, energy companies, financial institutions, local government, local population) within well-defined geographical areas.

1.4 Need for global coordination

Despite the many benefits and potential drivers of bioenergy use, and the ability of bioenergy to be competitive with fossil routes in some cases, there is still relatively low uptake of modern biomass systems worldwide. This is as a result of a number of barriers, associated with technical, economic, social and regulatory issues as well as with the relatively early stage of development of bioenergy sector and related policies and markets. These barriers will be discussed in greater detail in a later section.

There are many different bioenergy production routes, and considerable differences between the most suitable bioenergy systems for different regions, which can make overcoming the barriers for bioenergy as a whole appear difficult. However, there are many commonalities amongst the barriers faced by the different bioenergy routes, in relation to technology and policy development for example, and there is a role for international actions in assisting to remove these barriers. A number of international activities are already at work to assist the development and deployment of bioenergy in developed and developing countries, but additional action at the international level may be required to accelerate the development and deployment of sustainable bioenergy.

For this reason, the Italian Ministry for the Environment and Territory has proposed the establishment of the Global Bioenergy Partnership. It organised and hosted an International Workshop on Bioenergy in Rome in June 2005 to hear the views of G8 and developing country representatives. Many participants expressed interest in the idea, but felt that a greater understanding of the role and value of a Partnership was required and that a White Paper should be produced to this effect.

More recently, the G8 Gleneagles 2005 Communiqué endorsed the interest in a Partnership by stating that "We [the G8] will promote the continued development and commercialisation of renewable energy by: […] (d) launching a Global Bioenergy Partnership to support wider, cost effective, biomass and biofuels deployment, particularly in developing countries where biomass use is prevalent, following the Rome International Workshop on Bioenergy".

As a result of the discussions during the Rome workshop and after the endorsement of the G8, this White Paper on a Global Bioenergy Partnership has been prepared. The objective of the White Paper is to discuss how a Global Bioenergy Partnership could contribute to the development and deployment of bioenergy in developed and developing countries.

The paper is divided into the following sections:
Section 2: Summary of the status and potential of bioenergy
Section 3: International organisations promoting bioenergy worldwide
Section 4: Barriers to bioenergy deployment in developed and developing countries
Section 5: Areas where action is needed to overcome barriers
Section 6: Possible roles for a Global Bioenergy Partnership

2 Summary of the status and potential of bioenergy

A precise assessment of the total amount of biomass used worldwide for energy purposes is impossible because most of the feedstock is self-produced and self-consumed outside commercial networks, especially in developing countries. Also, the variety of bioenergy systems – in terms of feedstocks, conversion technologies and end uses – poses a challenge in assessing their contribution to future energy supply. Nevertheless, estimates of the present and future global energy contribution of this renewable resource can be made.

2.1 Bioenergy on the world scene

2.1.1 A global view

According to IEA Renewable Information 2004, biomass provides at present approximately 10.7% of the World Total Primary Energy Supply (WTPES) and 80% of the global renewable energy supply.

2002 World Energy supply (EJ) [1]	
WTPES	**428.4**
of which:	
Bioenergy	46.2
Hydroelectricity	9.4
Other renewables	2.1

The contribution of biomass to the world total primary energy supply is mainly in residential heat production. Only 1.1% of the world electricity production comes from biomass.
The bioenergy system is composed of:

- Solid biomass/charcoal providing 44.65 EJ
- Biogas providing 0.4 EJ
- Liquid biofuels providing 0.46 EJ
- Renewable Municipal Solid Wastes, providing 0.63 EJ

Different biomass shares and different approaches to bioenergy development are seen in various regions of the world, as reported in the following table. A very different situation is found in developing and developed countries.

[1] *1 EJ = 10^{18}J = 23.88 Mtoe*

Selected Bioenergy Indicators by World Region for 2002 *(IEA Renewable Information 2004)*
(Rounded figures in EJ)

Region	TPES (all sources) Mtoe	Of which total RES Mtoe	Share of RES in TPES %	Share of Biomass in total RES %	Biomass TPES e=d x b Mtoe	Biomass TPES f=e/23.88 EJ	Share of Biomass in TPES = e / a %
	a	*b*	*c*	*d*	*e*	*f*	
Africa	539.8	268.7	49.8	97.2	261.2	10.9	48.4
Latin America	454.8	129.2	28.4	62.5	80.8	3.4	17.8
Asia	1183.9	390.9	33	92.7	362.4	15.2	30.6
China	1245.0	242.3	19.5	89.8	217.6	9.1	17.5
Non-OECD Europe	99.7	9.1	9.2	55	5.0	0.2	5.0
Former USSR	930.5	27.7	3	29.1	8.1	0.3	0.9
Middle East	431.3	3.5	0.8	30	1.1	0.04	0.2
OECD	5345.7	304.2	5.7	54.6	166.1	7.0	3.1
EU-15	1489.43	84.35	5.66	60.58	51.1	2.1	3.4
World	**10230.7**	**1375.5**	**13.4**	**80.1**	**1101.8**	**46.1**	**10.8**

In developing countries, the non-commercial use of solid biomass ranks bioenergy before hydropower and other renewable sources of energy. In the poorest countries, biomass may contribute more than 90% of energy demand for cooking, heating and lighting.

In most developed countries, the contribution of biomass is much smaller at around 2-4% of primary energy supply. Some exceptions are Australia, and northern European Countries, such as Finland, Sweden and Austria where bioenergy covers approximately from 10% to 20% of primary energy supply. In the USA and EU15 the primary energy coming from biomass represents about 3.5% of the total primary energy supply.

Three main bioenergy sectors are currently being pursued, as they are seen to be promising for the future both in industrialised countries and those with economies in transition:

- Heat and power for domestic and industrial uses
- Biofuels for transport
- New biomass-derived fuels

2.1.2 Heat and power for domestic and industrial uses

Domestic cooking and household heating by means of stoves, fireplaces, and domestic and district heating boilers of several hundreds kW in size, are still the most widespread end-use of biomass energy.

In developing countries the main driver is the need to supply a minimum level of thermal energy for cooking and heating in rural households; various studies show that 70%-98% of total biomass consumption – for example, in Asian countries – occurs in the domestic sector. Traditional low-efficiency biomass-fired systems are still used, wasting scarce primary energy resources and posing

serious health problems as a result of indoor air pollution. Improved appliances have been introduced in many countries, raising the combustion efficiency from below 10% to above 25%. Millions of innovative stoves have been installed in China and India in the last 2 to 3 years, and charcoal derived from woody and non- woody biomass is used in countries member of the Association of South East Asian Nations (ASEAN), in both traditional and modern applications. With industrialisation, commercial energy consumption will increase, and so the share of biomass in total energy consumption is destined to fall in these countries unless more modern uses are supported. In some countries, the economic viability of biomass use is reduced by subsidies on fossil fuels for cooking, heating and for power generation.

In developed countries, however, the use of biomass is expanding in different sectors. In power generation, about 40,000 MW_e capacity is now installed worldwide in centralized and decentralized installations of several MW in size. Biomass district heating and heat and process steam production for manufacturing industries are also expanding. In these applications, biomass-based energy needs to be competitive with energy from fossil fuels. In general, biomass energy costs span a wide range depending on the cost of the raw material, the complexity of the equipment, and the conversion efficiency. In general, these costs are not competitive with fossil fuel energy, with higher investments cost of biomass installations, and higher feedstock costs in some cases. In many countries where biomass is used for heat and power, there are policy instruments providing financial support for biomass projects or for bioenergy production, but large differences exist between different countries, in terms of instruments used and of the success of implementation.
In the US, for example, many power plants are in operation, generating electricity from low-cost wood wastes and municipal solid wastes, with a total installed capacity of about 7,000 MWe. A further 4,000 MWe is forecasted in the short to medium term. In Austria, Italy and other northern EU countries hundreds of district heating plants are in operation ranging in size from 1 to 10 MW. This is mainly due to the promotion of district heating networks fed by wood chips, sawdust and other residues that must be disposed of in an environmentally benign way. In recent years combined heat and power plants, fed with residual biomass, have also been built and utilized for district heating. In Sweden and Finland a large share of domestic heating is provided through biomass-fuelled district heating plants.

The present world market for small-scale generators is large, estimated at about 50 billion $/year. However, reliable, efficient and low cost small-scale generators (10 - 500kW) fuelled with biomass are not commercially available today. Bioenergy could play a greater role in small-scale decentralised generation and help improve access to energy in the poorer parts of the world. This is an area where greater effort in technology development and diffusion is required.

2.1.3 Biofuels for transport

Environmental and health impacts of fossil fuel use, together with national energy security and balance of payments concerns have driven the use of biomass-derived ~~liquid~~ fuels in the transport sector as substitutes for diesel, gasoline or natural gas. Biofuels can decrease the pollution level caused in some microenvironments - such as urban centres - by cars and other motor vehicles fuelled by fossil fuels. At present about 30 billion litres per year (equivalent to 1 EJ) of biofuels for transport are commercialised in North and South America, Europe and South Africa.

Two kinds of liquid biofuels are in widespread use as substitutes for fossil fuels, or as enhancers of specific fuel properties such as octane or cetane numbers:

- Biodiesel (methyl or ethyl esters derived from vegetable oils) and vegetable oils, both of which can be used as a diesel component
- Bioethanol (ethyl alcohol obtained from sugar or starch crops) or its chemical derivative ethyl tertiary butyl ether (ETBE) used as a gasoline component

The choice of the two alternatives is country-specific. A different approach has been adopted in different countries: bioethanol is widely used in North and South America and to a limited extent in some EU Countries (Sweden, Spain, France, Germany); biodiesel is generally more widespread in European countries such as Germany, Austria, France and Italy. Recently, both types of liquid biofuels are experiencing growth in all mentioned regions.

There is also some use of biogas for transport: for example, in Sweden there are several thousand cars and nearly 800 buses running on biogas and biogas/natural gas mixtures, and tests are beginning on a biogas-powered train.

Even with current oil prices at around $60/bbl, the cheapest liquid biofuels cost around 40% more than the fossil equivalent. Advanced production routes (from FT diesel and lignocellulosic ethanol), which could lead to wider availability of biofuels at a reasonable cost, are expected to become commercially available sometime in the period 2015 to 2020. Therefore if the environmental and energy security benefits of biofuels use are to be realised, biofuels production or use will need to be supported by policy incentives. In several countries this is achieved through fuel tax reductions and capital grants to production plants, but in most cases these incentives are not guaranteed beyond the short term, presenting a risk to investment. In many other countries, there are no incentives of this kind.

Biodiesel

As a whole, Europe has the largest biodiesel production capacity estimated at 2 million tonnes per year in more than 40 dedicated installations mostly in Germany, France, Italy and Austria. Oleaginous crops that are usually considered for biodiesel production in Europe and the US are rape, sunflower and soybean; however palms and other oil-bearing trees are also considered mainly in tropical and subtropical regions, and there is also production from waste vegetable oils. Several bus and vehicle fleets have been demonstrated to operate reliably on diesel blend containing a greater that 30% share of biodiesel and on neat biodiesel. Generally, a 5% blend is available at refuelling stations in some European countries. There is also ongoing research into methods of biodiesel production from solid biomass via gasification, followed by Fischer-Tropsch (FT) conversion to a synthetic diesel substitute. This has benefits such as lower CO_2 emissions in production, the ability to use a wider range of feedstocks, more efficient use of land, and the potential for competitive production costs.

Bioethanol

The countries with the highest current use of bioethanol are Brazil (15 billion litres, representing about 30% of gasoline demand), the US (13 billion litres in 2004, representing about 2% of gasoline demand) and South Africa. Large-scale bioethanol programmes for transport have been driven in several countries by synergies with existing agro-industrial activities, such as sugar industries and markets, and by lead or MTBE replacement in gasoline. A blend of between 5% and 22% bioethanol in gasoline is generally used, although there are also flex-fuel and dedicated ethanol

vehicles. In some regions, the use of ETBE is preferred, as a result of improved handling and engine operating properties.

Ethanol is commonly produced from sugar crops such as sugar cane and sugar beet, and grains such as corn and wheat. The development of whole-crop processes for the production of multiple products (biorefinery concept) could lead to more efficient and economic processes, possibly at relatively small-scale. Other crops, such as sweet sorghum, suitable for cultivation in different regions, may have potential for producing biofuels and other products. Production of ethanol from lignocellulosic materials (e.g. corn stover, straw, wood, biodegradable solid wastes) is also in development, with several pilot plants in operation. This also has benefits such as lower CO_2 emissions in production, the ability to use a wider range of feedstocks, more efficient use of land, and the potential for lower cost production.

2.1.4 New biomass-derived fuels

Pyrolysis oils
Whereas conventional pyrolysis technique suffers from high charcoal yields, the newer fast and flash pyrolysis processes are characterised by high liquid product yield, say 70-80%, based on dry biomass. The use of this liquid product as a source for high volume chemicals or as fuel oil is currently under investigation. Pyrolysis oils can also be refined to derive a range of synthetic fuels that could be used in transport applications.

Hydrogen
Hydrogen is being considered as an energy carrier, particularly for transport, through use in a fuel cell or in an internal combustion engine. Whilst use of hydrogen has many benefits including zero emissions at point of use, CO_2 savings from hydrogen are greatest when it is produced from renewable sources, such as biomass.

Hydrogen can be produced from biomass in three main ways

- Gasification or pyrolysis of solid biomass followed by shift reactions or catalytic reforming
- Reforming of biogas
- Novel technologies based on use of photosynthetic algae or bacteria, or on fermentative bacteria

Gasification and biogas-based technologies are currently at the development stage, with novel biological routes at the research stage. Advanced gasification technology being developed for the production of synthetic fuels, including hydrogen, aims at conversion efficiencies of about 50%. Current costs are high, but there are projections indicating that costs could be competitive with those from steam reforming of natural gas for large-scale biomass gasification plants.

Pellets
Pellets provide a useful intermediate biomass fuel. The stabilisation of humid biomass by drying and pelletisation technologies limits the degradation and emissions from biomass raw materials with humidity contents higher than 10%. Also, pellets lead to a better quality and more easily transportable and storable fuel. There is scope for improvement in pelletisation technology, and pellets could provide a useful fuel for small and large-scale applications.

2.2 Future bioenergy potential

Bioenergy is the largest renewable energy source in the world and the fourth largest energy contributor after oil, natural gas and coal. But this raises the question: will bioenergy be able to maintain or increase its relative contribution in the future, and what is the total amount of biomass that can be exploited for energy production?

The rate of primary energy stored by terrestrial biomass is around 3000-3500 EJ/year, which is seven times the present world total primary energy supply. However, the majority of this resource cannot be used as it is inaccessible. The exploitation of the remaining accessible fraction is further limited by environmental constraints, the technical ability to extract energy from the raw material, and by socio-economic constraints including other uses of the material. Land could be converted to the production of biomass for energy, but this is also subject to environmental and socio-economic constraints. Given these constraints, many authors have considered scenarios for forecasting the future penetration of biomass into the energy market. The following table summarises different projections for the future role of bioenergy.

Future bioenergy potential scenarios (EJ/year)

Scenario	2025	2050
Shell (1996)	85	200 – 220
IPCC (1996)	72	280
Greenpeace (1993)	114	181
Johansson et al. (1993)	145	206
WEC (1993)	59	94 – 157
Dessus et al. (1992)	135	–
Lashof and Tirpak (1991)	130	215
Fischer and Schrattenholzer (2001)	350	450

Scenarios indicate that bioenergy could contribute between 100 and 500 EJ by 2050; this is two to ten times what is used today. Such growth would require greater action aimed at the promotion of bioenergy. Up to now, modern bioenergy use has not experienced rapid growth: in the last ten years the growth rate of solid biomass has been equal to 1.6% per annum, roughly equal to that of the world total primary energy supply. The highest growth, 7.4% per annum, has been experienced in municipal solid wastes, liquid and gaseous biomass.

The conversion efficiency of solar energy into biomass is low (generally between 0.1% and 2%). However, improvements in photosynthetic efficiency are possible and could have a major impact on the availability of biomass resources for energy. Developments in this area should therefore be pursued.

3 International organisations promoting bioenergy worldwide

3.1 Introduction

Over the past few decades biomass has become the focus of a number of national and international initiatives around the world, led by scientific institutions, government agencies, industries, non-profit organisations and others. Some of these organisations work specifically in the bioenergy sector, whereas others embrace the wider renewable energy sector or are focused more specifically on environmental and socio-economic concerns. Some operate at a world level, others at a regional level. Programmes, targets and action plans are specific for each organisation, but some objectives may be identified which are common to them all (for more details see Annex 1):

1. Promoting the transition from the traditional, inefficient use of biomass to a modern use, especially in developing countries
2. Disseminating information
3. Creating international partnerships

3.2 Global organisations

The United Nations Organisation has made a great contribution to bioenergy through the United Nations Development Programme (UNDP) and the Food and Agriculture Organisation (FAO), both operating at global level. The World Bank (WB) and the International Energy Agency (IEA Bioenergy) are also active in supporting bioenergy worldwide.

One of the most important programmes within **UNDP** is Energy and Environment. This programme is aimed at promoting sustainable development and ensuring a better quality of life, especially in poorer regions of the world where environmental degradation and lack of access to modern energy services can jeopardize survival. Promoting rural energy services, particularly energy for heating and cooking in rural households, is one of the priority topics of this programme. Assisting in moving towards more efficient use of resources, including the passage from traditional biomass use to modern use, is another important topic. To reach these objectives there is strong cooperation between local, national and international communities, in order to share information, know-how and best practice, and also to implement pilot projects. A constant commitment of UNDP is to expand dialogue and exchange ideas throughout the international community and to promote initiatives aimed at linking energy and poverty reduction.

FAO has over 20 years of experience in bioenergy, with a particular focus on fuel wood and agricultural resources for energy. Key issues relevant for FAO are: policy and institutions; capacity building; technical and economic issues. Dissemination of information is high on the FAO agenda and several programmes have been set up for this purpose such as the Wood Energy Information System (WEIS), the Unified Wood Energy Terminology (UWET), the Woodfuel Integrated Supply-Demand Overview Mapping (WISDOM), as well as a range of manuals and guidebooks. The FAO also provides important technical assistance to member countries for defining strategies, policies

and implementing projects. Cooperation with national, regional and international partners - including intergovernmental bodies, research and development centres and other UN organisations - are prerequisites for fulfilling the FAO's objectives.

The role of the **World Bank** in providing financial, analytical and advisory services in the area of Renewable Energy is well known and established, as well as its capacity to leverage greater investments from other sources. Several institutions provide financial support, such as the International Bank for Reconstruction and Development (IBRD), the International Development Association (IDA), the International Finance Corporation (IFC), the Multilateral Investment Guarantee Agency (MIGA), and the Carbon Finance Unit at the World Bank. In the last fifteen years, the World Bank Group has supported a wide range of renewable energy technologies, including biomass, hydropower, solar thermal, solar heating, wind, and geothermal. More than 140 projects on renewable energy received support, with a total commitment of 6.2 billion US$, of which 27 were on bioenergy. Integration of different renewable sources is also pursued in order to overcome the limits of each individual technology.

The main task of **IEA Bioenergy** is to improve cooperation and information exchange between countries that have national programmes in all sectors of bioenergy. IEA Bioenergy draws on an international pool of experts from research institutes and industrial corporations, who operate on a cost-sharing basis, on behalf of a contracting party appointed by national governments. IEA Bioenergy has twenty national members as well as the European Commission. An Executive Committee oversees IEA Bioenergy's activities and delegates to Operating Agents and Task Leaders. There are 12 tasks currently underway, embracing all aspects of bioenergy from biomass resources to supply systems, conversion, and end products. Annual reports and topic reports are issued on subjects relating to systems studies, advanced research, fuel standards, and barriers to deployment amongst others.

The **World Energy Council** (**WEC**), through its committees in over 90 countries, is committed to "promote the sustainable supply and use of energy for the greatest benefit of all people"; in this respect, bioenergy forms part of the Council's triennial renewables work programme. The 2005-2007 Work Programme includes studies on Energy Scenarios to 2050, a survey of energy resources and a regional project aimed at surveying the status of different forms of energy in various continents and regions.

3.3 Regional organisations

Many organisations operate active bioenergy programmes at a regional level; some of these are outlined below.

3.3.1 Africa

The **African Energy Policy Research Network** (**AFREPREN**) is active across the continent. Supported by the Government of Sweden, AFREPREN runs programmes on energy, environment and sustainable development. The network is composed of 97 researchers, policy-makers and decision-makers engaged in the formulation and implementation of energy policy in Africa. Policy research studies have been initiated in 19 African countries, with collaborative links active in a

further six countries. An important research programme was launched in 1999 focusing on renewable energy for rural development and energy services for the urban poor. Another area of activity is strategy setting for energy sector development in Eastern and Southern Africa, for which biomass is envisaged as an important energy source. In this context the transition from traditional use of biomass to modern biomass energy use is deemed necessary for ensuring benefits in terms of quality of life, conservation of biomass resources and better energy services.

3.3.2 Asia

The **Association of South East Asian Nations** (**ASEAN**) is co-ordinating bioenergy activities in member countries across Asia. Wood and agricultural residues represent about 40% of total energy consumption in these countries mainly in the domestic sector and in small-scale industrial applications. The main commitment of ASEAN is to define and pursue clear and consistent policies to maintain and enhance the present economic growth rate using improved and modern technologies for increasing the production and use of biomass as an energy resource. Bilateral and multilateral agreements have been established with other energy organisations as well as with the European Commission.

3.3.3 Australia

Bioenergy Australia is described as "a government-industry forum, established in 1997, to foster and facilitate the development of biomass for energy, liquid fuels, and other value-added bio-based products". The membership is composed of 43 partners from Government and industry. The main objective of Bioenergy Australia's activities is to create an awareness of bioenergy among stakeholders and decision-makers, fostering business and project opportunities. All aspects of bioenergy are taken into consideration and explored and as a result Bioenergy Australia is active in 5 of the IEA Bioenergy Tasks from 2004-2006: *Short Rotation Crops for Bioenergy Systems; Conventional Forestry Systems for Sustainable Production of Bioenergy; Biomass Combustion & Co-firing; Energy from Integrated Solid Waste Management Systems;* and *Greenhouse Gas Balances of Biomass and Bioenergy Systems*.

3.3.4 Latin America

The **Latin America Thematic Network on Bioenergy** (**LAMNET**) is a project funded by the European Commission supporting the promotion of biomass and bioenergy worldwide, but with Latin America as its core region. LAMNET is a network of 48 institutions with biomass expertise from 24 countries worldwide. The network's main activity is in policy recommendations, with a principal focus on small-scale technologies for decentralised applications. LAMNET has an extensive programme for information dissemination as well as for fostering international cooperation, facilitating technology transfer and initiating joint ventures based on use of modern bioenergy technologies.

3.3.5 North America

North America boasts a large number of organisations working on different aspects of bioenergy development, such as research and development, market prospects and business opportunities. These range from Federal and State Agencies to private corporations and non profit associations.

In the USA the strategies of the **Department of Energy** (**DOE**) and the **National Renewable Energy Laboratory** (NREL) are interested in biomass for decreasing the dependence on imported oil, strengthening rural economies and reducing pollutant emissions, especially those linked with transport fuels. Bioethanol and biopower have high priority at present, but "biorefineries" are being planned for the future with the aim of developing advanced technologies such as hydrolysis of lignocellulosic biomass to sugars and lignin and thermochemical conversion of biomass to synthesis gas as a feedstock for biopolymers, biodiesel and hydrogen. One of the implementation programmes pursued at present is the Regional Biomass Energy Program (RBEP). Five regions of the United States are involved in this programme, aimed at improving industry and government efforts to assess availability of biomass feedstock and identifying research needs.

The **United States Department of Agriculture (USDA)** conducts a broad research and development program in biomass feedstocks and biomass energy. The research and development program is conducted by agencies within USDA and focuses on: research, development, and demonstration of forest and agriculture crops, residues, and wastes having significant commercial potential for the production of bioenergy; agriculture, and forest management systems and equipment designs to produce, harvest, and transport efficiently biomass; decision support tools for evaluating technical and economic viability of biomass production and energy options at multiple scales; understanding and projecting the impacts of biomass energy on greenhouse gas emissions and carbon sequestration; developing and demonstrating integrated systems for production, management, harvest and delivery, utilization and conversion; and developing analytical tools to identify and analyze incentives and commercialization options."

In Canada, the **Canadian Biomass Innovation Network Research and Development Program** is a combined bioenergy/greenhouse gas mitigation program to harness the potential for bioresources, bioenergy, bioproducts and bioprocesses to help Canadian industry meet efficiency, sustainability and climate change challenges. The Program coordinates its activities with the Canadian provinces, universities, non-government and government research organizations to maintain a nationally focused effort on the development of biomass conversion technologies. The bioenergy component of the Program, in partnership with industry, provides cost-shared support for the development of new, or improvement of existing, technologies for conversion of biomass to energy. Technologies for biomass combustion and for biochemical and thermochemical conversion of biomass to fuels and chemicals are all under development in Canada.

3.3.6 Europe

In the European Union, modern biomass technology has been used since the early 1980s. The European Commission strongly promotes these activities through a range of methods including legislation, white papers, action plans, funding schemes and means of disseminating information. Particularly important are the recent activities in relation to a "Biomass Action Plan" aimed at delivering an increase in the contribution of biomass to EU energy supply from the present 50-60 Mtoe to 130 Mtoe by 2010. The Commission is also very effective in promoting collaboration between European countries, as described below.

The **Network of Excellence** (**NoE**) is a European organisation aiming at establishing a web-based 'virtual' R&D centre containing studies, analyses, and propositions put forward from the network's partners. Eight leading European Institutes in bioenergy research and development are partners of the NoE.

The European Biomass Association (**Association Européenne pour la Biomasse**, **AEBIOM**) is a non-profit international organisation that aims to encourage the study and promotion of bioenergy amongst its partners. AEBIOM was founded in 1990 by a small group of European national biomass associations and has expanded to its present membership of 28 national biomass associations. AEBIOM – with the support of national associations from Italy, France, Sweden and Slovenia – is coordinating the Biomass Section of a large multi-disciplinary EU Project aimed at producing and promoting a comprehensive Action Plan for heat from renewable energy sources (RES-Heat) in Europe. This project analyses public policies supporting renewable heat, identifies best practice, and develops concrete guidelines that are applicable at local, regional, national and European level.

The **European Biomass Industry Association** (**EUBIA**) is an international non-profit association founded in Brussels in 1996. As an umbrella for the biomass industry, EUBIA intends to contribute to strengthening European policies in this sector, by promoting industrial interests, identifying new opportunities, promoting job creation and improving environmental conditions. EUBIA has started co-operation activities with non-European countries, notably China and Brazil.

4 Barriers to bioenergy deployment in developed and developing countries

This section provides a summary of key barriers associated with the development of bioenergy chains for heat, electricity and transport fuel production. The summary is based on a more extensive review of barriers provided in Annex 2.

Many of the barriers are common to different bioenergy chains, and so are presented first. However, heat, electricity, biofuel and hydrogen production chains also have their own specific barriers, which are described at the end of this section.

4.1 Feedstock production

- Limited understanding of the land resource available and whether competition could arise between crops for food and crops for energy, especially in some developing countries
- Farmers' reluctance to switch to crops for biofuels due to start-up costs, uncertainties about profitability, limited routes to market, policy and market uncertainty, little familiarity with the crop management techniques and fear of long term land-use commitments with perennial crops
- Limited experience worldwide on growth of crops for energy, apart from where these are already grown for food. Yields of energy crops require improvement, both from improved plant varieties and agricultural practices
- Little experience in the systematic use of other types of biomass such as animal, agricultural and forestry residues for commercial or community energy purposes. In some regions there is a risk of competition for these resources with other uses such as animal feed and bedding, traditional energy and industrial wood production. There can also be low interest in collection of feedstocks for community or commercial projects due to the perception that biomass is not a modern fuel. As with energy crops, the market for the residues can be limited and uncertain, especially if supply is to a single plant, or if the market is created by policy
- Municipal solid waste collection and landfill sites are not energy-recovery focussed. In countries with developed waste collection infrastructure, waste policy tends not to be energy focussed. In other countries, the lack of waste infrastructure is a barrier

4.2 Feedstock transportation, pre-processing and trading

- There are a relatively small number of intermediaries trading non-food biomass feedstocks such as woodchips, pellets and straw in most countries
- This stage is seldom recognised as being vital to the whole chain: policy support often focuses on feedstock producers and conversion plants or end users without providing coordination, information or financial support to intermediaries that can mitigate market risk for the other stages of the chain

- Dispersed geographical distribution of feedstock producers and plants can make the fuel chain impractical or uneconomic, especially if transport infrastructure is weak
- Transporting biomass can involve significant costs especially if transported with no pre-processing
- There are financial barriers to collection and processing infrastructure such as chipping, pelletisation, waste sorting and to improved transport infrastructure

4.3 Domestic and small-scale commercial heat and CHP in developed countries

The adoption of domestic and small commercial boilers and combined heat & power systems (CHP) using biomass is hampered by several factors:

- Initial cost of replacing boilers with biomass technologies, and higher capex for biomass systems than for conventional technologies
- Wood chip systems can be competitive with oil-fired systems, but in most cases biomass systems have higher costs than conventional systems
- Limited policy incentives directed at renewable heat – either no supportive policies in the area, or policies supporting renewable electricity only
- Limited awareness of the benefits of biomass technologies, which are sometimes still perceived as inconvenient
- Some environmental aspects are not fully solved (e.g. air quality regulation for boilers used in urban environments)

4.4 Domestic and small-scale commercial heat and CHP in developing countries

Use of biomass for domestic and small-scale commercial or community scale heating, cooking or CHP systems in developing countries face several additional barriers:

- Low income and difficult access to financing limit the adoption of efficient end use technologies and ability to pay for commercial biomass feedstocks
- Subsidies for competing fossil fuels, such as kerosene, in some regions
- Few policy incentives for bioenergy deployment and lack of links between different policy areas (e.g. rural electrification and land use)
- Limited awareness of the benefits of biomass technologies, which are sometimes still perceived as a “fuel of the past”

4.5 Large scale power and heat

The additional barriers to large scale power and heat chains are:

- In many countries there is insufficient policy support for biomass electricity and heat, or for renewable energy in general, to allow biomass energy to compete with fossil energy

- The markets for biomass conversion plants at an early stage of development, resulting in greater level of perceived business risk for both suppliers and utilities, and problems with obtaining development and project finance for plants
- Whilst biomass combustion plants at a range of scales are commercially available, their efficiency could be improved, and costs further reduced. Technology improvements are also needed in areas such as gasification, plants using a variety of biomass feedstocks, polygeneration, co-firing using a range of feedstock
- Standardisation of feedstocks and technologies is needed
- The planning process for plants in developed countries can be difficult

4.6 Biofuels production

Feedstock production and transport barriers specific to biofuels:

- Current biofuel production is based predominantly upon crops also grown for food, such as sugar crops, grains and oil crops, for which there are fewer barriers than for new types of dedicated energy crop. However, new crops used for biofuels, such as *jatropha* or new lignocellulosic energy crop types that could be used for advanced biofuels such as lignocellulosic ethanol and Fischer-Tropsch biodiesel will face many of the barriers listed above
- Feedstock transport and logistics barriers are particularly important for biofuels production as conversion plants are generally at a medium to large scale

There are several important barriers to conversion from feedstock to biofuel:

- Conversion technology: bioethanol and biodiesel are produced commercially in a number of countries; however, advances are possible and will be required for current processes, in particular in relation to improved efficiency and greenhouse gas balance of biofuel production, and production scales
- Significant research and development efforts are still required to bring advanced conversion technologies (lignocellulosic ethanol and FT biodiesel) to market
- Plant cost and financing: the level of capex required for conversion plants is significant; in the absence of specific policies, it is difficult to obtain financing; also, where plants are built, this can result in cheaper, less advanced and less efficient technologies being preferred
- Uncertainty on both fuel market and availability of biomass supply

For fuel distribution and use, there are fewer technical barriers than in other sectors, but a lack of market pull in most countries:

- Biofuel compatible end-use technologies are already available (e.g. cars operating on neat or blended ethanol and biodiesel); however the levels of biofuels blended with fossil fuels may be limited by vehicle warranties. There is a need for a more widespread introduction of vehicles in the market with greater fuel flexibility, and for vehicles that can run on biogas
- The adoption of biofuels is very region-specific resulting in limited systematic experience in the development of biofuel infrastructure (e.g. ethanol transport and blending)
- Lack of internationally agreed and adopted technical standards for biofuels limits the potential for international trade and introduces further uncertainty to equipment and technology suppliers

- Lack of environmental and social traceability may become an increasing concern, therefore there is a need to develop environmental and social standards for biofuels
- Biofuels are generally not competitive with fossil fuels. They are therefore only widely adopted where specific policy instruments are used to favour them, such as fuel duty reduction, production subsidies and public procurement

4.7 Hydrogen

Hydrogen is not yet commercially used as an energy carrier for road transport. However, it is still necessary to consider the additional barriers that hydrogen will face as its use develops, and to ensure that support measures for bioenergy do not preclude hydrogen options. Additional barriers to hydrogen chains are given below:

- Few countries currently have policy support for hydrogen production from biomass, and biomass to hydrogen is often considered as an afterthought by both the hydrogen and biomass policy communities. Hydrogen falls between policy areas in most countries, and so lacks institutional framework
- Hydrogen production opportunities may be overlooked in resource assessments, through lack of knowledge about hydrogen, and lower real or perceived long term market
- Biomass gasification to hydrogen is at the demonstration stage, and needs further development to improve efficiency, reduce capital and operating costs, work at a range of scales and accept more variable and mixed feedstocks. Once developed, these gasifiers will also require skills in operation and maintenance. Gas cleaning systems for biogas reforming require standardisation and cost reduction. Hydrogen production from photosynthetic bacteria and algae and dark fermentation are still at the R&D stage
- Financing for large gasification plants may be difficult as a result of the early stage of technology development, and may rely on success of gasification in the power sector
- Lack of information about benefits and safety features of renewable hydrogen and hydrogen in general may lead to concerns over plant and infrastructure siting and safety, and planning barriers
- More widespread experience and skills in hydrogen transport as compressed gas by road or pipeline, or as a liquid are needed in most regions, together with refuelling station planning, design and operation. Technical standards for hydrogen equipment and infrastructure are still in development
- Capital costs for hydrogen supply infrastructure are high, and it is currently unclear who will bear these costs
- Hydrogen use requires new vehicle technology – internal combustion engine or fuel cell vehicles, which are still in an early stage of development and require technology improvement, significant cost reduction, and development of international standards
- There is likely to be consumer uncertainty over purchase of a new fuel and vehicle

5 Areas where action is needed to overcome barriers

The previous section reviewed the existing barriers to bioenergy development.
The principal barriers affecting the development of bioenergy could be addressed under a number of areas of action.

5.1 National and regional policy

- Need for evidence-based policymaking directed at bioenergy, based on national energy demands and policy goals
- Need for supportive demand-side policy in transport, heat and power, together with information provision to consumers
- Need for policy integration among agriculture, land use, waste, forestry, industry, energy, transport and environment sectors
- Need for regional plans identifying opportunities for bioenergy deployment covering:
    - resource potential
    - possible conflicts with other land uses or feedstock uses (food, forestry, animal bedding, industry)
    - projects to meet local demand or export markets
    - links between bioenergy and development
- Need for support for bioenergy policymaking strategies in developing countries, including policies for domestic heating and cooking

5.2 International standards and information flows

- Need for an effective flow of information between governments and international institutions
- Need for international standards for feedstocks and fuels
- Need for certification schemes to allow traceability of environmental and social benefits
- Need for cooperation with the automotive industry to broaden vehicle standards and availability, and with oil companies to develop infrastructure
- Need for greater coordination among donors on bioenergy projects in developing countries
- Need for removal of international trade barriers

5.3 Functioning projects and markets

- Need to mitigate the risk of lack of local market stability, e.g. no flexible and secure feedstock markets – need for support e.g. through project clusters, feedstock exchanges, etc.
- Need to attract intermediaries: information provision and finance availability
- Need to facilitate access to development and project finance for plants

- Need for local skills in plant development, operation and maintenance
- Need for improved logistical efficiency – e.g. infrastructure, transport planning
- Need for appropriate methods for community involvement in project design and implementation
- Need for small scale projects such as domestic heating, cooking and CHP systems to be deployed in sufficient numbers to gain acceptance and economies of scale
- Need for more effective dissemination of information on successful examples of use of biomass resources to project developers and funders

5.4 Biomass resources

- Need for further energy crop development to improve yields and widen suitability
- Need for information and support to farmers on
    - new crop types
    - use of residues
    - market opportunities and risks
- Need for information provision on waste to energy to MSW industry, together with policy measures to promote this
- Need for information to the forestry industry on wider energy opportunities
- Need for integrated biomass feedstock production, management, harvest and delivery, utilization, and conversion systems

5.5 Developing and transferring technologies

- Need for strategic planning of biomass conversion research, development and demonstration
- Need for improvement of environmental performance of biofuel plants and range of economically viable scales for plants
- Need for development of gasification at a range of scales, with a range of feedstocks, to support power, heat, FT biodiesel and hydrogen production
- Need for RD&D on advanced biofuels technologies: lignocellulosic ethanol and FT biodiesel
- Need for RD&D on hydrogen technologies: gasification, biogas reforming and biological routes
- Need for effective knowledge and technology transfer among disciplines and geographical regions
- Need to consider development and deployment of appropriate technologies based on local considerations

6 Possible roles for the Global Bioenergy Partnership

This section provides a summary of the possible activities by which a global partnership could contribute to overcoming the barriers to bioenergy deployment.
The different activities share some common elements and so are grouped into five thematic areas:

- Supporting national and regional bioenergy policymaking
- Facilitating international cooperation in bioenergy
- Promoting development of bioenergy projects and markets
- Supporting biomass feedstock supply through information and research
- Encouraging development and transfer of biomass conversion technologies

For each thematic area, the areas where action is needed are first presented. As it might not be feasible, necessary or appropriate for the Global Bioenergy Partnership to act in all of them, the principal current activities in each area are then described. Finally, possible roles for the partnership are discussed.

6.1 Supporting national and regional bioenergy policymaking

Areas where action is needed:

- Support the adoption of evidence-based bioenergy policymaking processes, based on national energy demands and policy goals
- Support bioenergy policymaking capacity in developing countries
- Promote the adoption of demand-side policies supporting bioenergy in transport, heat and power (e.g. aimed at factoring in the positive externalities of bioenergy and removing distortions favouring fossil fuels)
- Promote policy integration among agriculture, land use, waste, forestry, industry, energy, transportation and environment sectors
- Assist with the development of national/regional bioenergy plans covering:
    - resource potentials
    - possible conflicts with other land uses or feedstock uses
    - possible impacts of bioenergy policies on land tenure and inequality
    - projects matching resources and uses to meet local demand or export markets
    - links between bioenergy deployment and socio-economic development
    - avoiding over dependence on one crop type or technology to reduce market risk

Main current activities in these areas:
The Energy Sector Management Assistance Programme (ESMAP) set up by the World Bank and the UNDP focuses on poverty reduction through sustainable energy; the targets are developing and transition countries.
FAO is also active in this area, its focus being particularly on policy integration among the different sectors, by establishing links between policymakers and key stakeholders at national and international levels.
As regards the development of national and regional resource plans, there are important activities in progress, e.g. FAO and LAMNET in Latin America.

REN21 is a global policy network aimed at stimulating renewable energy through policy development at the sub-national, national and international level.

Possible roles for the Partnership:
The following areas with limited international coverage were identified, where a partnership could contribute:

- Help governments understand how bioenergy could contribute to address national policy priorities, and how bioenergy could help developing countries with wider development objectives, including the Millennium Development Goals
- Support governments in developing national bioenergy policies through the adoption of effective policy frameworks and instruments
- Help developing countries build policymaking capacity, e.g. through the promotion of international secondment schemes
- Assist the development of conversion and end use strategies to link with bioenergy resource plans; e.g. those developed by FAO and LAMNET

6.2 Facilitating international cooperation in bioenergy

Areas where action is needed:

- Ensure access to information and knowledge exchanges between governments, international organisations and industry
- Enhance the coordination between governments and donors, as well as among donors, in order to maximise the effectiveness of projects
- Develop internationally agreed standards for feedstocks and end use products
- Promote and support the adoption of biofuel and biomass resource certification schemes to allow traceability of environmental and social performance
- Clarify the position of bioenergy with respect to CDM and JI mechanisms
- Assess the effect of trade barriers on bioenergy
- Promote the integration with other renewable energy activities

Main current activities in these areas:
FAO aims at promoting bioenergy as a means for development, its emphasis being on agricultural and forestry resources.
IEA Bioenergy aims at improving cooperation and information exchange between countries that have national programmes; its focus is more on end-use conversion technologies.
Other international activities, in particular IEA Task 40 and AEBIOM, cover specifically trade barriers. Also, IEA Bioenergy Task 38 is involved in Greenhouse Gas aspects of Biomass and Bioenergy systems.
Finally, the International Partnership on Hydrogen Economy is working to overcome the barriers to the deployment of hydrogen energy, thus addressing the common areas of biomass routes to hydrogen.

Possible roles for the Partnership:

- Gather or integrate existing information – links to existing information in a structured way – e.g. fact sheets on resources and technology chains
- Keep G8 countries engaged, bring other key bioenergy players in, and ensure that commitment remains strong over time
- Work to improve coordination between government and donors, as well as among donors;
- Work with IEA Task 40, ISO and industry to develop international technical, environmental and social standards
- Work with ISO and existing voluntary certification schemes in food and forestry e.g.: by providing a forum on environmental and social certification
- Work with IPHE and other international hydrogen initiatives to ensure that biomass to hydrogen is covered in both hydrogen and biomass activities
- Engage in international activities (e.g. WTO) aimed at assessing the effect of trade barriers on bioenergy
- Develop links with other partnerships, institutions or agencies that work on possibly complementary renewable energy resources, and define common plans of actions
- Raise awareness of bioenergy in other organisations that are working in related areas, but whose focus is not bioenergy, and that could have a positive impact e.g. OECD Task Force on Biotechnology for Sustainable Industrial Development, APEC Energy Working Group
- Secure eligibility of projects to improve traditional biomass energy use (e.g. cooking stoves, charcoal) under the Clean Development Mechanism (CDM)

6.3 Promoting the development of bioenergy projects and markets

Areas where action is needed:

- Help to reduce the risk of local market instability, e.g. by promoting the creation of national and local project clusters or feedstock exchanges
- Help to reduce exposure to world market risks e.g. by promoting diversification to reduce dependence on one crop, technology or route to market
- Help attract intermediaries, e.g. by improving the availability of information and financing opportunities
- Improve access to finance, specifically for bioenergy conversion systems, including small-scale domestic systems, by:
    - helping reduce the perceived risk associated with bioenergy projects in the financial community
    - promoting bioenergy in funding institutions (e.g. WB, regional development banks);
- Ensure that small-scale systems such as domestic heating and CHP are deployed in sufficient numbers to gain acceptance and achieve economies of scale
- Create skills, at local level, for the development, operation and maintenance of plants
- Improve logistics of feedstock markets, e.g. through infrastructure development and transport planning
- Promote methods for community involvement in project design and implementation

Current activities:
There is relatively little activity in this area, supporting market building and intermediaries. A,B,C-REED (Rural Energy Enterprise Development) supports entrepreneurship including for biomass intermediaries, although this is currently limited by the lack of market opportunities.
National, regional and international development banks have financing schemes, including microcredit, in developing countries. Organisations including the World Bank and GEF provide project funding for biomass, and other financing mechanisms such as risk guarantee schemes. The Global Forum for Sustainable Energy develops finance mechanisms and promote public-private partnerships. However, in developed countries, there appear to be few organisations providing information to the financial community about bioenergy.
Community involvement in bioenergy projects is promoted by numerous NGOs and funding organisations at a local level, and may also be supported by the FAO as part of its approach to biomass as a development tool.

Possible roles for the Partnership:
- Identify promising market-building opportunities – for example where there could be synergies between several types of bioenergy production in one region, or opportunities for international linkages – and initiate discussion between stakeholders
- Promote local market stability, e.g. by encouraging the creation of national and local project clusters through grouping donor-supported projects and by disseminating information on successful market-building examples
- Support policies that promote diverse bioenergy routes in each region or country, as opposed to those that promote one particular crop, technology or market
- Emphasise the importance of intermediaries to policymakers and funding bodies, and ensure that this role is not overlooked in project planning
- Disseminate information to the financial community in developed and developing countries about bioenergy technologies and markets to help reduce perceived risk and improve access to finance for plants
- Promote bioenergy in funding institutions (e.g. WB, regional development banks), including microcredit, e.g. by assisting with the design of financing schemes and programmes
- Encourage national policymakers and donors to establish training schemes and skill sharing missions for the development, operation and maintenance of plants
- Establish networks of government, non-government and private sector organisations that could serve as an informal mechanism to facilitate communication, develop projects, and stimulate private sector involvement
- Raise importance of bioenergy infrastructure planning at government level, and promote involvement of those with logistics experience from other sectors in bioenergy projects
- Promote information sharing between groups experienced in methods for community involvement in project design and implementation
- Establish a fund for RD&D in bioenergy systems, possibly under a Global Bioenergy Partnership branding

6.4 Supporting biomass feedstock supply through information and research

Areas where action is needed:

- Provide centralised information on regional biomass resources, best practices and lessons learned, by gathering and rationalising existing information
- Help identify national RD&D priorities and define strategies to promote further energy crop developments, e.g. higher yields or wider suitability
- Promote support for farmers in the form of information on biomass opportunities and of financial support:
    - information on crop types and management techniques
    - information on the potential for collection of crop residues
    - availability of finance for new crop establishment and new equipment
    - information and advice on local routes to market and the opportunities and risks of feedstock markets
- Provide information to the forestry industry, on wider bioenergy opportunities from timber, forestry residues and wood processing residues, and how these can interact with current markets
- Promote MSW to energy routes both within the waste industry and in the waste policy community, emphasising the dual benefits of waste disposal and energy production
- Ensure sustainability of biomass production – both environmentally, in terms of biodiversity, land use change, water use and soil erosion and quality, and socially, through ensuring community rights, land tenure and good working practices

Current activities:

Several organisations provide some information on biomass resources, such as LAMNET in South America, USDA/DoE in the US and EUBIONET in the EU, however this is not available in all regions. FAO is likely to develop activities in this area.

Internationally IEA Task 30 focuses on the development of short rotation crops for bioenergy. There are also some crop-specific networks. At a national level, some countries have programmes on energy crop development.

Support for farmers is covered by national, regional and local programmes in many countries. At an international level, there appears to be little information provision on how to engage and support farmers' involvement in bioenergy.

IEA Task 31 works on biomass production for energy from sustainable forestry, focusing on knowledge transfer within the forestry sector. National forestry associations in some countries are active in this area.

IEA Task 36 (energy recovery from MSW) and Task 37 (energy from biogas and landfill gas) work on mainly technical aspects of bioenergy from MSW. There is limited activity on information sharing on integrating energy production into waste policy.

Possible roles for the Partnership:

- Assist with coordination of existing activities on resource information provision
- Identify gaps in RD&D on crops suitable for developing countries, and promote establishment of international activities and national RD&D on these crops
- Instigate activities aimed at providing information and support to farmers, and sharing knowledge on successful promotion of bioenergy to farmers

- Encourage information sharing between national forestry associations on bioenergy, with focus on developing countries
- Provide centralised information on the benefits of waste to energy and on available technologies, to the waste industry and the waste policy community, emphasising the dual benefits of waste disposal and energy production
- Develop guidelines on the sustainability of biomass production in collaboration with organisations involved in resource production
- Promote education and training on bioenergy systems, e.g. through the involvement of academic institutions
- Establish a fund for RD&D in bioenergy systems

6.5 Encouraging the development and transfer of biomass conversion technologies

Areas where action is needed:

- Develop an international knowledge base on biomass conversion technologies, and aggregate existing information;
- Help identify national and international priorities and define strategic plans for of RD&D activities, in particular on:
    - improving efficiency and environmental performance of biomass conversion technologies, and their range of economically viable scales
    - advanced biofuels technologies: lignocellulosic ethanol and FT biodiesel
    - hydrogen technologies: gasification, biogas reforming and biological production routes
    - cooperation between feedstock and conversion technology development
    - polygeneration ('biorefineries')
    - vehicle technologies for higher biofuel blends, biogas and hydrogen
- Promote technology transfer between geographical regions, both N-S and S-S
- Ensure that the development and deployment of bioenergy technologies are based on consideration of local conditions

Current activities:

The IEA Tasks on bioenergy conversion technologies (32-38) and well as IEA hydrogen tasks cover RD&D on the technologies listed. Many countries have national RD&D programmes on some of the technologies. There are some organisations promoting technology transfer such as EUBIA EU-Russia agreement, LAMNET (EU-Latin America), REEEP.

Possible roles for the Partnership:

- Exchange with other international activities to provide more integrated and effective knowledge on bioenergy – for example work with FAO and IEA to create web-based information systems on resources and end-uses
- Raise awareness within national governments of bioenergy R&D needs
- Support IEA Bioenergy activities, and encourage further participation from developing countries

- Ensure strong links between biomass and hydrogen R&D activities, for example within the IEA and within national RD&D plans
- Promote technology transfer between geographical regions, both N-S and S-S, for example through technology development partnerships
- Encourage cooperation between regional and local technology end users and technology developers to ensure that the development and deployment of bioenergy technologies are based on consideration of local conditions
- Promote education and training on bioenergy systems, e.g. through the involvement of academic institutions
- Establish a fund for RD&D in bioenergy systems

7 Conclusions

This document provides a first step towards identifying the potential role of the Global Bioenergy Partnership. Through a review of the barriers to bioenergy development and deployment and a review of current international activities in the bioenergy sector, it identifies areas where action is needed, and so potential roles for the Global Bioenergy Partnership.

A number of high level messages can be derived from the analysis. If a Partnership is to have an impact in accelerating the development and deployment of bioenergy globally, it needs to:

- have a wide and balanced participation from developed and developing countries
- develop a global understanding of bioenergy opportunities and issues
- raise awareness on the barriers and how to overcome them
- establish close links with existing international activities and provide leverage to these activities
- actively involve private sector in the Partnership
- establish networks of government, non-government and private sector organisations
- have political weight to promote bioenergy effectively

The next step is to develop the Terms of Reference of the Partnership, based on suggestions provided in this White Paper and suggestions from future Partnership members. The Terms of Reference will specify the mission, boundaries, composition, structure and activities of the Partnership.

Annex 1: International initiatives

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
FAO International Bioenergy Programme http://www.fao.org/sd/dim_en2/en2_050302a1_en.htm	FAO, Imperial College London, Utrecht University	Worldwide, but focus on developing countries	All bioenergy, but with emphasis on supply side	Information provision and capacity building	Mission is to promote biomass as development tool fighting poverty and climate change, to provide framework to support pro-poor bioenergy system, to ensure dissemination of scientifically sound info regarding biomass and promote research into sustainable bioenergy Objectives include: Mobilising stake-holders through collaboration, support and acting as point of contact Creating web-based information hub and synthesise disparate info sources Developing mechanisms to clarify conflicts with food prod Promoting bottom-up sustainable bioenergy plans at local level	Recognises need for cross-sector involvement and stakeholder led initiatives Split into 2 pillars: - Bioenergy action mobilisation - Bioenergy info systems Interesting part of pillar 2 is partnerships. E.g. interaction between UN Energy, IEA, WEC, DFID, ENEA, Ministries, DEFRA, USDOA, ADEME, USAID, Shell, BP Solar, ENI. Aims to compile and mediate international bioenergy policy
IEA Bioenergy http://www.ieabioenergy.com/	20 OECD countries + EC (now some tasks open to non-OECD countries)	OECD	All bioenergy supply and consumption	Facilitating exchange and promoting R&D	Founded by IEA in 1978 with the aim of improving cooperation and information exchange between countries that have national programmes in bioenergy research, development and deployment. 12 tasks are currently pursued: - Socio-Economic Drivers in Implementing Bioenergy Projects - Short Rotation crops for Bioenergy Systems - Biomass production for Energy from Sustainable Forestry - Biomass Combustion and Co-firing - Thermal Gasification of Biomass - Pyrolysis of Biomass - Energy Recovery from Municipal Solid Wastes - Energy from Biogas and Landfill Gas - GHG Balance of Biomass and Bioenergy Systems - Liquid Biofuels from Biomass - Sustainable International Bioenergy Trade	Focuses on R&D for production and conversion of biomass and wastes; implementation concerns are strictly linked to socio-economic aspects, as well as to GHG mitigation.

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
					- Bioenergy System Analysis	
EU Bioenergy Action Plan http://europa.eu.int/comm/energy/res/biomass_action_plan/index_en.htm	EC TREN Interservice Steering Group External Stakeholder Group External Expert Group	EU25	All bioenergy supply and consumption	Coordination of EU biomass policies to achieve RES target by 2010	Aim is to streamline several EU policies on energy, agriculture, environment, regional policy, as well as to propose new initiatives. The BAP Impact Assessment will aim to identify the impacts on these areas these and propose a structure to achieve them.	
EUBIA-Russia framework agreement www.eubia.org	EUBIA and Russian Federation of Science and Innovation	Russia and EU	All bioenergy supply and consumption	Technical cooperation to advance and implement new technology	Aim is that both parties will facilitate the implementation and widening of the scientific-technical cooperation on progressing energy-efficient technologies and systems for biomass energy use and the application of these technologies on the base of equality and mutual benefits	EUBIA – European Biomass Association - is an international non-profit association open to all companies and organisations that have an interest in the area of biomass and bioenergy.
Latin America Thematic Network on Bioenergy (LAMNET) http://www.bioenergy-lamnet.org/	48 institutions funded by EC, led by WIP Renewables (DE), EUBIA and ETA-Renewable Energies (IT) with CENBIO (Brazil), UNAM (Mexico), CAREI (China)	South and Central America and Mexico	All bioenergy supply and consumption	Information provision and capacity building	Aim is to establish a trans-national forum for the promotion of sustainable use of biomass in Latin America and other emerging countries. Main thrust is identification of technological objectives and the development of policy options to boost promotion of decentralised biomass production and biomass based energy generation The Lamnet network is mainly directed to: Identify currently available, efficient, cost-competitive and reliable small scale decentralised bioenergy technologie for the conversion of biomass to energy services in Latin America, Europe, Africa and China. Disseminate information on current activities through the publication of a periodic newsletter, a project database and the organisation of several bioenergy workshops. Identify and promote opportunities for international co-operation, technology transfer and joint-ventures between OECD and non-OECD countries, based on application of modern bioenergy technologies especially in the field of ethanol production in the Brazilian, South African and Cuban sugarcane industries as well as in China, to aid rural	Will create database on website and publish periodical newsletter

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
					development.	
BioEnergy Future Group http://www.accstrategy.org/	NGO creating bioenergy network	Global but recent focus on CHINA	All bioenergy supply and consumption	Platform for information exchange and dialogue	To support the global drive for sustainable development by promoting bioenergy solutions	Workshop with Chinese authorities 7-8 July 2005 Currently registering as NGO in Japan
ESMAP www.worldbank.org/html/fpd/esmap/	World Bank / UNDP	Various developing and transition economies	All bioenergy supply and consumption	Technical assistance and consensus building	Founded in 1983 by World Bank and UNDP to promote the role of energy in poverty reduction and economic growth in an environmentally responsible manner. Its work applies to low-income, emerging, and transition economies and contributes to the achievement of internationally agreed development goals.	Recent publication "Advancing Bioenergy for Sustainable Development" aimed at informing decision and policy makers in policy setting for bioenergy
World Bank projects http://web.worldbank.org/external/projects/main?query=biomass&menuPK=224076&pagePK=218616&piPK=217470&theSitePK=40941	World Bank	Various developing and transition countries	Biomass conversion	Funding individual projects via loans	Aims to create efficient energy markets open to all investors in order to provide sustainable affordable energy services to all Example projects: Moldova – funding demonstration best-practice small-scale biomass plants Benin – Increase rural access to modern energy services, restructure traditional biomass utilisation with best-practice Bulgaria – funding to install biomass cofiring at one large power plant Sri Lanka – funding to promote off-grid small scale renewable projects include biomass	
UNDP GEF projects http://www.undp.org/gef	GEF	Various developing / transition countries	Bioenergy projects that meet GHG reduction criteria	Funding via risk guarantee mechanisms	The Global Environment Facility (GEF), established in 1991, helps developing countries fund projects and programs that protect the global environment In relation to bioenergy, the GEF has been involved with funding large biomass generation plants in Slovenia and Thailand via risk guarantee schemes	The GEF's projects are in the framework of the general objectives of the UNDP's Energy and Environmental Programme: Strengthening national policy frameworks, Promoting rural energy services, Promoting clean energy technology, Increasing access to financing for energy,

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
A,B,C-REED (Rural Energy Enterprise Development)	UNEP Energy dept UN foundation	1. Africa 2. Brazil 3. China	Some bioenergy relevance	Funding support for entrepreneurs	Entrepreneurship support for all renewable and energy efficient projects. Some involvement in biomass in Brazil, Tanzania and China	Limited emphasis on biomass
REN21 - Renewable Energy Policy Network for the 21st Century www.ren21.net	Government representatives, NGOs, intergovernmental organisations, industry	World	Policy	1. Policy support 2. Advocacy 3. Knowledge exchange	REN21 is a global policy network aimed at providing a forum for international leadership on renewable energy. It was established following the political declaration after the International Conference on Renewable Energies held in Bonn in 2004	
Global Forum for Sustainable Energy GFSE www.gfse.at	GFSE is a multi-stakeholder platform based in Austria	Global with emphasis on Africa	All bioenergy supply and consumption	5th annual meeting focus on biomass	GFSE as a whole orchestrates dialogues to facilitate decision-making on policy issues in the appropriate fora, foster public-private partnerships, and promote concrete cooperation endeavours in the field. GFSE was founded by Austrian Foreign Minister in 1999. The 5th annual meeting focused on enhancing global cooperation on biomass. Special emphasis was placed on building up institutional capacity to promote South-South cooperation on biomass.	Recommendations from GFSE-5 : 1. Improving biomass trade: stimulating research to aid planning and to reduce cost of technology (eg IBTs) 2. Modern biomass: Develop new finance mechanisms and promote capacity building 3.Biofuels: Create policy framework, promote R&D, encourage PPP 4.Power gen: promote CHP use 5.Promote international cooperation including developing countries
Renewable Energy and Energy Efficiency Partnership (REEEP) www.reeep.org	REEEP is a PPP launched by UK but based in Austria with NGO status	Global	Some biomass conversion projects	Financing new projects	The REEEP aims to work as an enabler, multiplier and catalyser of institutional change. The partnership finances projects that either identify replicable models of **policy** and regulatory frameworks that overcome the market barriers to renewable energy or projects which leverage additional resources and enhance capacity building for investors, financiers and public officials.	Past biomass projects include: • Financing med to large scale biomass cogeneration projects in Kenya/Tanzania • Attracting farmers to biomass in the Philippines • Communicating Benefits and Testing Biogas Digester for Rural Communities
Mediterranean Renewable	ADEME, IEA, ISES ITALY,	Mediterranean	Some biomass	Developing financial	The two principal objectives of the program are: - to provide modern energy services particularly to rural	Promoting biomass projects along with other RE technologies

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
Energy Programme (MEDREP) www.medrep.it (under construction)	MEDENER, OME, REC, UNEP & World Bank	countries	conversion projects	mechanisms, strengthening policy and fortifying private sector infrastructure	populations; - to contribute to the climate change mitigation by increasing the share of renewable energy technologies in the energy mix in the region.	
L'Asssociation Europeenne pour la Biomass AEBIOM	28 national biomass associations	EU Countries	Current focus is on heat chains	Promoting bilateral and multilateral agreements for development of bioenergy in EU countries	AEBIOM is a non-profit international organisation. Its objectives are the study and promotion of bioenergy, notably: • To develop, deepen and disseminate the knowledge concerning the use of biomass for energy, from scientific, technological, economic, sociological, legal and political perspectives, as well as in any other aspect having a relevance at European level; • To develop and promote the technical quality of the European bioenergy industry; • To support any initiative at national and international level aiming at the promotion of the use of bioenergy ; • To communicate to policy makers the opportunities and concerns regarding the development of bioenergy in Europe. • To actively promote the abolition of any technical or trade barriers which hamper the development of an open bioenergy market at European level.	AEBIOM was a pioneer in promoting collaborations between West and East European countries. A better knowledge of the situation in these two European Regions and common projects derived from this collaboration.
African Energy Policy Research Network: AFREPREN..	The network is composed by 97 researchers, policy- and decision-makers engaged in the formulation and implementation of energy policy in	Africa	Biomass as energy source for rural communities	Promoting the transition from traditional use of biomass to modern use	An important research programme was launched in 1999 with the following key themes: • Renewables and Energy for Rural Development; • Energy Services for the Urban Poor; • Energy Sector Reform; • Special Studies of Strategic Significance for the Energy Sector Development in Eastern and Southern Africa.	

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
	Africa.					
Bioenergy Australia www.bioenergyaustralia.org	43 members from Government and Industry	Australia	All aspects of bioenergy	Forum for development	Bioenergy Australia activities: • Creating an awareness and understanding of biomass energy to a broad range of stakeholders and customer groups • Producing a quarterly newsletter to foster interest and involvement in the biomass industry. Bioenergy Australia also holds an annual conference, which is coupled to a trade/sponsor exhibition, and invariably includes technical tours to bioenergy facilities • Facilitating the development of market, business and project opportunities • Broadening the support base for the Bioenergy Australia to ensure its continued role in promoting biomass energy in Australia • Forming and managing groups to participate in the International Energy Agency's Bioenergy program.	
Association of South East Asian Nations-ASEAN www.asean.org	Asiatic Countries	Asia	All aspects of bioenergy	Defining policy and development tools	Enhancing socio-economic growth rate through the modern use of biomass	Multilateral agreements are in force also with the European Commission
DOE -Department of Energy www.energy.gov	USA Government	USA	Biopower and liquid biofuels, biorefinery	Policy	Decreasing USA fossil fuel dependence and mitigating environmental pollution through the use of bioenergy	A Regional Bioenergy Plan involving 5 USA regions is in force
USDA – United States Department of Agriculture www.usda.gov	US Government	USA	Feedstock, biopower and biofuels, biobased products, biorefinery	Policy, research and technology development, assistance	Promoting the development and use of renewable agriculture and forestry resources for biobased products and bioenergy	
Network of Excellence –NoE www.bioenergy-noe.com	8 leading European Institutions	Europe	All aspects of bioenergy	Virtual centre for studies, analyses, scenarios	Promoting research and developing of new technologies and systems	

Initiatives	Participants	Geographic Focus	Fuel Chain focus	Role and activities within Bioenergy	Aims	Notes
World Energy Council-WEC www.worldenergy.org		World	All aspects of bioenergy and other energy sources	Studies, surveys and scenarios	Surveying and monitoring different forms of energy all over the world. Defining scenarios and strategies.	

Annex 2: Barriers

A2.1 Biofuels

Chain step	Production of biomass	Collection and transportation	Conversion	Fuel distribution	End-use application
Technical	Food crops are well developed, energy crops are still at an early stage, e.g. need to determine suitability for different regions, and increase yields Farmers' unfamiliarity with energy crops or with different food crops Some regions have real or perceived problems with land availability for crops In some countries, agricultural scale may not be concentrated enough to provide feedstock for medium-large scale plants Little experience with use of other feedstocks for biofuel uses in many countries	Need to avoid long transport distances to minimise cost/CO2 impacts of bulky biomass material– inhibits dispersed production to supply centralised plants Insufficient infrastructure – road, rail, canal, sea – in some countries Adequate feedstock storage needed to mitigate feedstock supply risk Lack of experience of collection and handling for energy crops Lack of experience on MSW source or post-collection separation	High plant capex and high plant cost; this applies especially to most efficient conventional plants and for advanced technologies No experience with plant construction and operation in many countries – lack of skills and technical support Lack of technologies for small scale production that could be more appropriate for local production in developing countries Technology development needed for advanced plants - lignocellulosic ethanol, FT biodiesel	Lack of technical standards in some countries Fuel distribution infrastructure and lack of experience with fuel blending in some countries Insufficient infrastructure – road, rail, canal, sea – in some countries	Limits to blending percentage for ethanol and conventional biodiesel for conventional vehicles. Low uptake of multi-fuel vehicles in most countries Biogas use requires modified vehicle technology, and there is relatively low availability of these vehicles in some vehicle classes
Financial	Few for conventional crops High establishment costs for switching to non-food crops, and risk of lock-in Risk from growth of new crops and uncertain, inflexible, market for output	Infrastructure and start up costs for collection and processing (crushing, chipping, sorting etc) of all feedstock types	Very difficult to get plant financing in all countries except those with strong supportive policy, as a result of high plant risk: technical, feedstock supply, market for fuel and for co-products Difficulty in valuing co-products Plants with increased	Some capital costs to fuel companies for adapting fuel supply infrastructure, for blending equipment and modified fuel storage Capital costs of	Initial costs for biogas vehicles compared with conventional ones may cause a barrier

Chain step	Production of biomass	Collection and transportation	Conversion	Fuel distribution	End-use application
	Little economic driver for energy recovery from residues and waste in many countries		mechanisation, and so cheaper outputs, may not be favoured in developing countries due to higher capital requirements	biogas refuelling equipment	
Policy & regulatory	Insufficient policy support for biofuels in general leads to lack of market pull Lack of regional plans identifying opportunities for energy crops and residues Concern over use of food land for fuel production in some regions Energy crops with mechanised methods, and tree crops with lower labour requirements than food crops may not be favoured in some countries Lack of policy support in developed countries for waste to energy – waste policy is not energy focussed Lack of developed waste policy and collection infrastructure in many developing countries	Lack of realisation that this part of the chain must be strong in order for chain to work, and fewer actors at this stage leads to a lack of policy support for intermediaries	Most countries have little support for plants (e.g. capital grants) Few countries have policy driver for advanced technologies, including increased support Planning for plants is problematic in many countries There may be barriers to export of co-product electricity in some countries	Varying technical standards for fuels International trade policy – tariffs for import of biofuels, different tariffs for different ethanol gradings Lack of standards enabling traceability of different biofuels	Biofuels falls between several policy areas in most countries – lacks institutional framework Few countries have effective support policies for biofuels' use Policies may favour one fuel over another Subsidies to fossil fuels No policy support favouring environmentally beneficial fuels: e.g. no ability to monetise carbon savings Uncertainty over benefits of different biofuel chains, in particular on carbon balance, hinders policy development Air quality-focussed policies do not favour liquid biofuels Need for international agreements on vehicle warranties Few countries have incentives for flex fuel vehicles Need for revenue from fossil fuel taxation in many countries does not favour small scale distributed biofuel production

Chain step	Production of biomass	Collection and transportation	Conversion	Fuel distribution	End-use application
Social	NGO/local concerns over environmental impact of energy crops and residue use NGO/local concerns over possible conflicts with land for food/other uses of residues Concerns over international trade of feedstocks from unsustainable sources Local concerns over loss of jobs with changes in crops Crops for export markets may not be suited for local social and environmental benefits	NGO/local concerns over environmental impact of feedstock transport	Maybe be local opposition to siting of new plants Lack of information about biofuel benefits Plant technologies and project management structures developed for developed countries may not be appropriate in developing countries, and so may need to be adapted to benefit the community	Some opposition to international biofuel trade - developing countries not benefiting from their own biofuel production	Lack of awareness of biofuel benefits Uncertainty over purchase of new fuel and vehicle Uncertainty over long term fuel price if this depends on price support Lack of information about biofuel benefits
Market	Fluctuating prices as a result of link to other markets e.g. food and animal feed Trade distortions in agricultural markets Lack of market for energy crops and competition with other uses of biomass may hinder fuels from woody crops and residues in the longer term	Lack of market pull for development of bioenergy feedstock supply infrastructure Limited presence of intermediaries and professional logistics experience in some countries and for some feedstocks Lack of trading market for some feedstocks Barriers to international feedstock trade	Relatively small number of technology developers, each with existing country focus Lack of feedstock market and uncertainty over security of feedstock supply – limited trading possibilities Lack of product market pull Markets strongly dependent on local policies and regulations – difficult global or regional outlook for industry Lack of co-product markets/risk from increased production	World ethanol market exists World biodiesel market less so Lack of standards enabling traceability of different biofuels	Biofuels cost more than fossil alternatives in most countries No premium market for biofuels Lack of demand for environmentally beneficial fuels

A2.2 Domestic and small commercial heat and CHP/ developed countries

Chain step	Production of biomass	Collection and transportation	Transformation and end-use application
Technical	Little experience of systematic collection and use of forestry and other wood residues for commercial energy purposes in many countries Energy crops are still at a reasonably early stage, e.g. need to determine crop suitability for different regions, and increase yields. Farmers unfamiliar with energy crops	Need to avoid long transport distances to minimise cost/CO2 impacts of bulky biomass materials Lack of experience of collection and handling for energy crops Relatively little experience of pelletisation in many countries – also could improve energy use/CO2 emissions of process	Relatively little experience with biomass boiler and CHP installation and servicing in many countries Lack of proven standardised systems for small-scale CHP and community scale gasification-based CHP systems Old equipment may not meet new emissions regulations Fuel storage requirements can be prohibitive
Financial	High establishment costs for switching to non-food crops, and risk of lock-in with long-term contracts for perennial crops Risk from growth of new crops and uncertain, inflexible, market for output may inhibit farmers Little economic driver for energy recovery from forestry and agricultural residues and waste in many countries	Infrastructure and start up costs for collection and chipping/ pelletisation	Initial cost of replacing boilers with biomass technologies Higher capital costs compared with conventional systems
Policy & regulatory	Lack of sufficient market pull from the heat market, because of limited incentives to renewable heat Lack of regional plans identifying opportunities for energy crops and residues Policy measures to support biomass feedstock production in some countries are focussed on biofuels or electricity production, not on heat		Lack of appropriate incentives for renewable heat and heating and CHP systems, compared with renewable electricity in many countries Uncertainty over compliance of biomass heating to air quality regulations
Social	NGO/local concerns over environmental impact of energy crops NGO/local concerns over possible conflicts with land for food/other uses of residues	Environmental impacts of more frequent fuel deliveries (compared with gas/oil systems)	Perception of biomass being an 'inconvenient' fuel Uncertainty of supply May be resistance to siting of district heating

Chain step	Production of biomass	Collection and transportation	Transformation and end-use application
	Local concerns over loss of jobs with changes in crops		
Market	Economics of energy crops not viable under current conditions (yield, revenues) Lack of secure and flexible market for products apart from in areas with strong forestry/wood industry	Small number of wood pellet/chip suppliers for domestic/small commercial heating markets leads to lack of market flexibility and end user choice	Gas heating/CHP generally cheaper. Biomass may be competitive with oil fired heating

A2.3 Domestic and small commercial heat and CHP / developing countries

Chain step	Production of biomass	Collection and transportation	Transformation and end use
Technical	Pressure on biomass resources in some areas from overexploitation for traditional domestic heating and cooking, and may be conflicting uses of animal wastes and crop residues In some regions there are real or perceived problems with land availability for food and energy crops Very limited experience with energy crop plantations, or work on adapting these for developing countries Need to develop multifunctional crops to meet developing countries' range of priorities	Few barriers for small-scale rural community systems Need to avoid long transport distances to minimise cost/CO2 impacts of bulky biomass material Insufficient infrastructure – road, rail, canal, sea – in some countries Lack of experience of collection and handling for energy crops	Variety of cooking and heating applications make standardisation of cooking and heating technologies difficult Lack of proven standardised systems, especially for small-scale CHP and community scale gasification-based CHP systems
Financial	Prohibitive capital investment for planting and related infrastructure for energy crops, especially when compared with traditional wood/residue collection	Capital required for start-up of intermediaries, and for transport infrastructure	Inability to pay for improved equipment leads to use of rudimentary technology, in particular for heating and cooking in some countries Inability to pay for bioenergy in many cases Higher capital investment of bioenergy installations compared to fossil equivalents. Plants generally owned by end users. These are particularly sensitive to capital costs, and may lack financing
Policy & regulatory	Focus on other priorities e.g. food production	Little supportive policy in this area	Lack of links between rural electrification/energy policy and land use

Chain step	Production of biomass	Collection and transportation	Transformation and end use
	Biomass not seen as a fuel for development Lack of regional plans identifying opportunities for energy crops and residues		and environmental policy Lack of incentives linked to possible environmental and development benefits of bioenergy Lack of policy framework to leverage private and donor funds – in particular for rural energy
Social	Local/NGO concerns over conflicts with land for food/other uses of residues and environmental impact of energy crops Possible resistance to new crop growth e.g. concerns over loss of jobs with changes in crops Lack of information on sustainable biomass exploitation		Lack of information from institutions on sustainable biomass use Lack of awareness in public and commercial sector of bioenergy uses Bioenergy not perceived as 'modern'
Market	Focus and value is in food markets Limited wood fuel market (some charcoal market)	Very few players in commercial fuel trading	Lack of established supply chains Subsidies to fossil fuels in some countries –e.g. kerosene

A2.4 Large scale power, heat and CHP

Chain step	Production of biomass	Collection, pre-processing and transportation	Conversion and end-use application
Technical	Limited knowledge on availability and suitability of land for energy crops Energy crops are still at an early stage, e.g. need to determine crop suitability for different regions, and increase yields and yield certainty Lack of commercial equipment for establishment and harvesting of energy crops Farmers' unfamiliarity with non-food crops Little experience with collection of wood	Different feedstock types require different infrastructure Need to avoid long transport distances to minimise cost/CO2 impacts of biomass material– inhibits dispersed production to supply centralised plants Insufficient infrastructure – road, rail, canal, sea – in some countries Adequate feedstock storage needed	Developments required in some technologies – e.g. gasification, use of some feedstocks Need for technology development to enable plants to accept wider ranges of feedstocks or mixed feedstocks – to mitigate feedstock supply risk Inconsistent characteristics of biomass feedstocks – need for optimised pre-processing Skills may not be available to operate some of the conversion and power plants, and lack of local technology suppliers and support

Chain step	**Production of biomass**	**Collection, pre-processing and transportation**	**Conversion and end-use application**
	residues, agricultural residues, MSW, green waste for biofuel uses in many countries	to mitigate feedstock supply risk Lack of experience of collection and handling for energy crops Lack of experience on MSW source or post-collection separation	services in developing countries Lack of widespread experience with co-firing with fossil fuels Poor track record of some technologies e.g. small scale gasifiers Many waste treatment plants and landfills not optimised for energy production
Financial	High establishment costs for switching to non-food crops, and risk of lock-in with long-term contracts for perennial crops Risk from growth of new crops and uncertain, inflexible, market for output Little economic driver for energy recovery from forestry and agricultural residues and waste in many countries	Infrastructure and start up costs for collection and processing (chipping, sorting etc) of all feedstock types Costs of establishing infrastructure for MSW collection and sorting particularly high, especially in some developing countries where there is less waste infrastructure	Generally higher capital cost or higher energy product cost for bioenergy systems compared to fossil equivalents Chicken and egg problem: no finance available for new technologies (e.g. gasification) → no plants → no track record of performance to support investments Problems with obtaining financing for small-scale projects Higher risks in financing power projects in developing countries and limited capital availability
Policy & regulatory	Insufficient policy support for commercial scale energy crop growth in general leads to lack of market pull Lack of regional plans identifying opportunities for energy crops and residues Concern over use of food land for fuel production in some regions Lack of certification schemes (giving value to sustainable energy crops) Lack of policy support in developed countries for waste to energy – waste policy is not energy focussed Lack of developed waste policy and collection infrastructure in many developing countries	Lack of realisation that this part of the chain must be strong in order for chain to work, and fewer actors at this stage leads to a lack of policy support for intermediaries General lack of policy support for better exploitation of residues and waste for energy	Bioenergy is common to different policy areas (energy, environment, agriculture), leading to a risk of conflicting policies or policy gaps Bioenergy drivers (CO2 etc) are not currently strong policy drivers in many countries In many cases policies do not provide sufficient incentives or risk mitigation to accelerate bioenergy deployment Most countries have little support for plants (e.g. capital grants) Difficulties in obtaining planning permission. Burden to obtain permission is disproportionately high for small plants R&D support is more likely to go to radically new technologies than to incremental advances. Limited support to advanced conversion technologies research and demonstration Externalities associated with fossil fuels are not fully reflected in their price / need policy intervention to internalise Barriers to grid connection in some countries
Social	NGO/local concerns over environmental impact of energy crops and residue use NGO/local concerns over possible conflicts	Concerns over environmental and amenity impacts of biomass collection and transport	Maybe be local opposition to siting of new plants, especially for waste plants Public perception of biomass plants as polluting; associated with old

Chain step	**Production of biomass**	**Collection, pre-processing and transportation**	**Conversion and end-use application**
	with land for food/other uses of residues Concerns over international trade of biomass feedstocks from unsustainable sources	infrastructure	waste combustion based plants Plant technologies and project management structures developed for developed countries may not be appropriate in developing countries, and so may need to be adapted to benefit the community
Market	Lack of market pull for bioenergy feedstocks Insufficient development of upstream market structure (too few suppliers, unpredictability) apart from in areas with strong forestry/wood industry Unfamiliarity of players (e.g. in farming, forestry) with new market (energy) Uncertainty about a stable, long-term policy framework increases perceived risk Economics of energy crops not viable under current conditions (yield, revenues)	Lack of market pull for development of bioenergy feedstock supply infrastructure Limited presence of intermediaries and professional logistics experience Lack of trading market for some feedstocks Barriers to international feedstock trade	Uncertainty over security of feedstock supply – limited trading possibilities Limited understanding of distribution of risk and value along the fuel chain on the part of project developers and financiers Lack of established technology and service provider in bioenergy in many areas Lack of level playing field (e.g. subsidies to fossil fuels) Markets strongly dependent on local policies and regulations – difficult global or regional outlook for industry

A2.5 Hydrogen

Chain step	Production of biomass	Collection and transportation	Conversion	Fuel distribution	End-use application
Technical	The same barriers will apply to feedstocks for as for the other chains – as energy crops, residues, MSW, and wet wastes can be used for hydrogen production. However, hydrogen production opportunities may be overlooked in resource assessments, through lack of knowledge about hydrogen, and lower real or perceived market pull for hydrogen Policies supporting biomass production financially will also need to be defined so as to allow hydrogen production	The same barriers apply to collection and transportation of feedstocks for hydrogen production by biomass gasification as for the other chains. Hydrogen production from biogas reforming and photosynthesis and fermentation routes will have few barriers in this area.	Biomass gasification to hydrogen is at the demonstration stage, and needs further development to improve efficiency, reduce capital and operating costs, work at a range of scales and accept more variable and mixed feedstocks. Once developed, these gasifiers will also require skills in operation and maintenance. Biogas reforming is technically feasible, though requires gas cleaning in many cases, using systems that are not standardised and are high cost. Hydrogen production from photosynthetic bacteria and algae and dark fermentation are still at the R&D stage	Hydrogen transport as compressed gas by road or pipeline, or as a liquid is used industrially, but is not widespread More widespread experience and skills in these areas are needed in most regions, together with refuelling station planning, design and operation	Hydrogen use requires new vehicle technology – internal combustion engine or fuel cell vehicles, which are still in an early stage of development and require technology improvement (fuel cell, hydrogen storage) and significant cost reduction
Financial			Financing for large gasification plants may be difficult as a result of the early stage of technology development, and may rely on success of gasification in the power sector. This may be less of a barrier for smaller biogas and biological plants	High capital costs for hydrogen supply infrastructure, and currently unclear who will bear these costs	Purchase costs for hydrogen vehicles are likely to be significantly higher initially than conventional ones

Chain step	**Production of biomass**	**Collection and transportation**	**Conversion**	**Fuel distribution**	**End-use application**
Policy & regulatory			Few countries currently have policy drivers for hydrogen production from biomass Biomass to hydrogen is often considered as an afterthought by both the hydrogen and biomass policy communities	Technical standards for hydrogen equipment and infrastructure are still in development Significant infrastructure changes may meet planning barriers Lack of standards enabling traceability of different biofuels will not favour biohydrogen	Few countries have effective support policies for hydrogen production and end use technologies, and specifically renewable hydrogen use Hydrogen falls between several policy areas in most countries – lacks institutional framework Policies may favour one fuel over another Subsidies to fossil fuels No policy support favouring environmentally beneficial fuels: e.g. no ability to monetise carbon savings Uncertainty over benefits of different fuel chains, in particular on carbon balance, hinders policy development Need for international vehicle standards
Social			Lack of information about benefits of renewable hydrogen and hydrogen in general may lead to concerns over plant siting and safety	Lack of information about benefits of renewable hydrogen and hydrogen in general may lead to concerns over infrastructure siting and safety	Lack of awareness of benefits of renewable hydrogen and hydrogen in general Uncertainty over purchase of new fuel and vehicle Uncertainty over long term fuel price if this depends on price support
Market			Small number of technology developers Lack of market and policy signals on the role of biomass in future hydrogen markets, and on future hydrogen markets themselves Markets strongly dependent on local policies– difficult global or regional outlook for industry	No market pull – need for infrastructure development to match demand growth	Hydrogen currently cost more than liquid biofuel and fossil alternatives in most countries No premium market for hydrogen Lack of demand for environmentally beneficial fuels

Annex 3: Areas for actions

A3.1 National and regional policy

Area for action	Current activities	Notes
• Need for supportive demand-side policy in transport, heat and power		
• Need for policy integration among agriculture, land use, waste, forestry, industry, energy, transport and environment sectors	FAO	Broad network of stakeholders
• Need for regional plans identifying opportunities for bioenergy deployment covering:		
○ resource potential		
○ possible conflicts with other land uses or feedstock uses (food, forestry, animal bedding, industry)	FAO	Broad network of stakeholders
○ projects to meet local demand or export markets		
○ links between bioenergy and development		
• Need for support for bioenergy policymaking strategies:	REN21	Renewables in general
○ in developed countries, to share past experiences		
○ in developing countries, including policies for domestic heating and cooking		
• Need for consistent assessment methodologies to support bioenergy resource planning and policymaking	IEA bioen. task 38	Focus on methodologies for GHG accounting

A3.2 International standards and information flows

Area for action	Current activities	Notes
• Need for an effective flow of information between governments and international institutions		
• Need for international standards for feedstocks and fuels	IEA bioen. task 39	Coordinates biofuels stakeholder panel
• Need for certification schemes to allow traceability of environmental and social benefits		
• Need for cooperation with the automotive industry to broaden vehicle standards and availability, and with oil companies to develop infrastructure		

Area for action	Current activities	Notes
• Need for a greater integration between bioenergy and fossil energy technologies	Maybe FAO	Not clear what the role of oil industry is
• Need for greater coordination among donors on bioenergy projects in developing countries	FAO	Broad network of stakeholders
• Need for removal of barriers to international trade	IEA Bioen. task 40	
• Secure elegibility of projects to improve traditional biomass energy use (e.g. cooking stoves, char coal) under the Clean Development Mechanism (CDM).	IEA Bioenergy Task 38, FAO	

A3.3 Functioning projects and markets

Area for action	Current activities	Notes
• Risk of lack of local market stability, i.e. no flexible and secure feedstock markets – need for support e.g. through project clusters/ bioenergy product exchanges	IEA bioen. task 40	
• Need to attract intermediaries: information provision and finance availability		
• Need to facilitate access to development and project finance for plants		
• Need for local skills in plant development, operation and maintenance		
• Risk of market distortions for bioenergy products (e.g. CO_2 externalities, ETS)		
• Need for improved logistical efficiency – e.g. infrastructure, transport planning		
• Need for appropriate methods for community involvement in project design and implementation	FAO IEA Bioen. task 29	Broad network of stakeholders Mostly CBA

A3.4 Biomass resources

Area for action	Current activities	Notes
• Need for further energy crop development to improve yields and widen suitability	IEA bioen. task 30	
• Need for information and support to farmers on		
○ new crop types		
○ use of residues		

○ market opportunities and risks		
• Need for information provision on waste to energy to MSW industry, together with policy measures to promote this	IEA bioen. task 36 IEA bioen. task 37	37 has focus on organic fraction of SMW and AD

A3.5 Developing and transferring technologies

Area for action	**Current activities**	**Notes**
• Need for strategic planning of biomass conversion research, development and demonstration (including large-scale "lighthouse" demonstration programmes)	IEA Bioenergy task 30 IEA Bioenergy task 41	
• Need for improvement of environmental performance of biofuel plants and range of economically viable scales for plants	IEA bioen. task 39	
• Need for RD&D on advanced biofuels technologies: lignocellulosic ethanol and FT biodiesel	IEA bioen. task 34 IEA bioen. task 39	Main focus: pyrolysis
• Need for effective knowledge and technology transfer among disciplines and geographical regions		
• Need for development of gasification at a range of scales, with a range of feedstocks, to support power, heat, FT biodiesel and hydrogen production	IEA bioen. task 33	
• Need to consider development and deployment of appropriate technologies based on local considerations		